

“Water runs like  
a river through  
our lives, touching  
everything from our  
health and the health  
of ecosystems around  
us to farmers’ fields  
and the production  
of the goods  
we consume.”



Peter Gleick  
*The World's Water*



## KEY RESULT AREA 1

# Sustainable Use and Supply

**Desired Result:** *An adequate and reliable supply of suitable quality water to sustain human and ecological needs for the next 30 years.*

**What does sustainable use and supply mean?** An integrated approach to managing our water resources is necessary to meet current and future human and ecological needs. Competition for water to meet the needs of homes, cities, farms and industries is increasing. At the same time, the importance of water in the streams and rivers for environmental and recreational uses is also growing. It is necessary to ensure, for now and the future, that the demands we put on our water resources do not exceed what they can sustain.

**Why is integrated management important?** The Basin Plan advocates the integrated management of water resources. This means considering the many fundamentally interrelated aspects of the water resource in decision-making, including:


- Water quality and quantity
- Surface and ground water
- Demand and supply management
- Environmental, social, and economic dimensions
- Legal dimensions

**Water quality and water quantity are interrelated characteristics.** Traditionally, policy makers have addressed water supply and water quality as separate issues, even though they are fundamentally interrelated characteristics of the water resource. Poor water quality affects water supply by increasing the costs of treatment and, in some cases, rendering the water resource unsuitable for potable use. Reduced flows in streams may decrease both the capacity of streams to assimilate point and nonpoint source pollutants, and impair the suitability of water for downstream users and aquatic life. Persistent low flow conditions can lead to warmer water temperature, increased nuisance plant growth and algal blooms, and lower dissolved oxygen levels, causing stress and damage to native aquatic communities. During wet weather, stormwater runoff can increase the loadings of bacteria, sediment, salts, pesticides, nutrients, and hydrocarbons from the land. High flow conditions can also scour stream channels and damage the filtration ability of flood plains.

**Surface and ground water are inextricably linked.** Another tradition that has confounded wise management has been the artificial separation of ground water and surface water issues. In fact, this separation is a matter of time and location, not of an inherent difference in the resource. Water is a limited resource cyclically exchanged between the earth and atmosphere. Precipitation that infiltrates the soil re-emerges as flow to streams and lakes or recharges ground water. Maintenance of ground water levels, through the natural process of infiltration and recharge, supports stream base flows, surface water quality and healthy aquatic ecosystems. Additionally, the geology of ground water systems can influence the character and quality of surface water systems. One example of this can be seen in the impact of



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“We forget that the water cycle and the life cycle are one.”

Jacques Cousteau

acidic mine drainage waters, where runoff from exposed bedrock materials can lead to pollution of waterways if not properly treated.

**Demand and supply must be in balance.** Demand can be reduced by using water more efficiently. This includes decreasing losses through distribution systems, employing conservation habits and incentives, encouraging technological innovation for increased efficiency, and re-using or recycling water. Options to enhance supply include surface storage, Aquifer Storage and Recovery (ASR), conjunctive use, and stormwater management. Soil conservation and wetland protection also contribute to storage potential by maintaining the natural storage capacity of soils and wetlands.

**Environmental and social consequences must be reconciled with economic costs and benefits.** Water is transient, limited in quantity, and subject to profound changes in quality from human use and landscape alterations. Thus, water has social and economic as well as environmental dimensions. Cleaner water in source water streams, rivers and reservoirs requires less treatment, enabling the supply of safe drinking water at a lower cost to residents and other users. Cleaner water means healthier fish, shellfish and waterfowl, lower risk to public health, and healthier economies. Healthy river corridors and waterscapes are aesthetically pleasing. They form a foundation for economically significant recreational activities and enhance the quality of life in our communities.

**Diverse legal and regulatory regimes and principles must be coordinated.** Historically, common law has dealt separately with ground and surface water withdrawals. Sound management requires a regulatory framework that establishes uniform principles for ground water and surface water and considers the interrelationships between them.

Laws addressing water quality are distinct from equitable principles governing interstate flow and from state laws governing intrastate water rights. Integrated management involves coordinating these legal regimes. Stormwater management laws and ordinances generally focus on controlling peak flows during and following development, yet the volume of runoff and infiltration amounts can also affect stream flows, water quality and ecosystems, and should be part of this focus.

## Goals for Sustainable Use and Supply

- 1.1 Equitably balance the multiple demands on the limited water resources of the Basin, while preserving and enhancing conditions in watersheds to maintain or achieve ecological integrity.
- 1.2 Ensure an adequate supply of suitable quality water to restore, protect and enhance aquatic ecosystems and wildlife resources.
- 1.3 Ensure an adequate and reliable supply of suitable quality water to satisfy public water supply and self-supplied domestic, commercial, industrial, agricultural, and power generation water needs.
- 1.4 Ensure adequate and suitable quality stream flows for flow-dependent recreational activities.

**Goal 1.1: Equitably balance the multiple demands on the limited water resources of the Basin, while preserving and enhancing conditions in watersheds to maintain or**

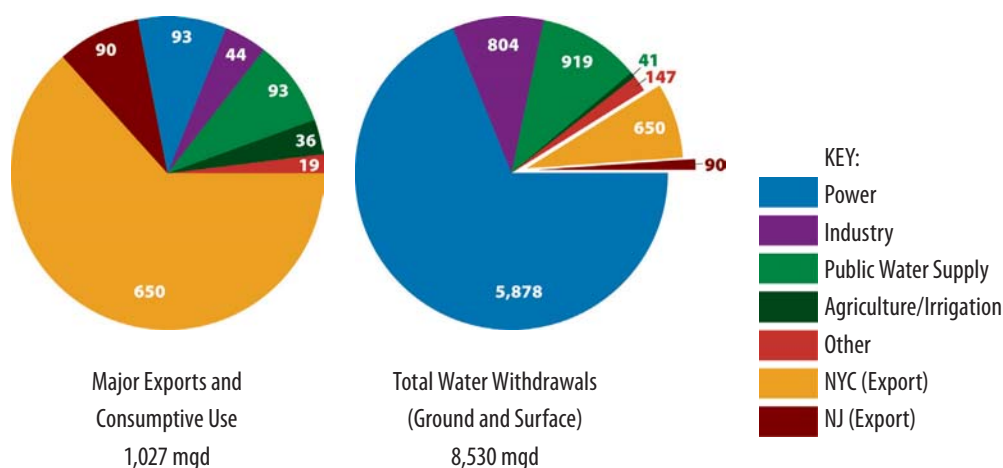
**achieve ecological integrity.** To equitably balance multiple demands, it is essential to understand the types of human and ecological demands being made on the hydrological system. To set realistic targets for preserving and enhancing conditions in watersheds to maintain or achieve ecological integrity, requires a clear understanding of existing conditions, and of the needs of aquatic and riparian populations. Those watersheds that currently approximate natural conditions should be protected to preserve their ecological and hydrological functions and those that have been degraded should be considered for restoration or enhancement.

**Assessing current water use.** Improving our understanding of water use will help us to manage resources more effectively and focus our efforts to promote efficient water use. The generation of reliable data requires accurate and up-to-date records on all ground water and surface water withdrawal allocations, wastewater discharge permits, and connectivity among withdrawal, use, and discharge points. Data management problems currently hamper the development of a precise water use and discharge data set for all watersheds in the Basin. However, existing information for individual watersheds can be used to estimate water use in other watersheds with similar conditions.

A summary of water withdrawals, exports and consumptive use in the Delaware River Basin based on data from 1996 is shown in Figure 3. There are two major exportations of water from the Basin. The largest (approximately 650 mgd) is to New York City, which obtains around half of its water supply from a system of upper Basin reservoirs that provide the water and make releases to the river designed to ensure a minimum rate of flow. The other major export (approximately 90 mgd) from the Basin is via the Delaware and Raritan Canal, which carries water to northeastern New Jersey. Limitations on these exports, of 800 mgd and 100 mgd respectively, were established by the Supreme Court Decree in 1954. The New York City aqueduct system and the Delaware and Raritan Canal are illustrated in Figure 4.

The largest water using sectors in the Basin are those of power generation, industrial use and public water supply. In recent years, at the Basin-wide scale, industrial water use has declined whereas water demand for power generation has increased. For public water supply, conservation efforts have helped keep demands

**Figure 3:** Summary of 1996 Water Withdrawals in the Delaware River Basin



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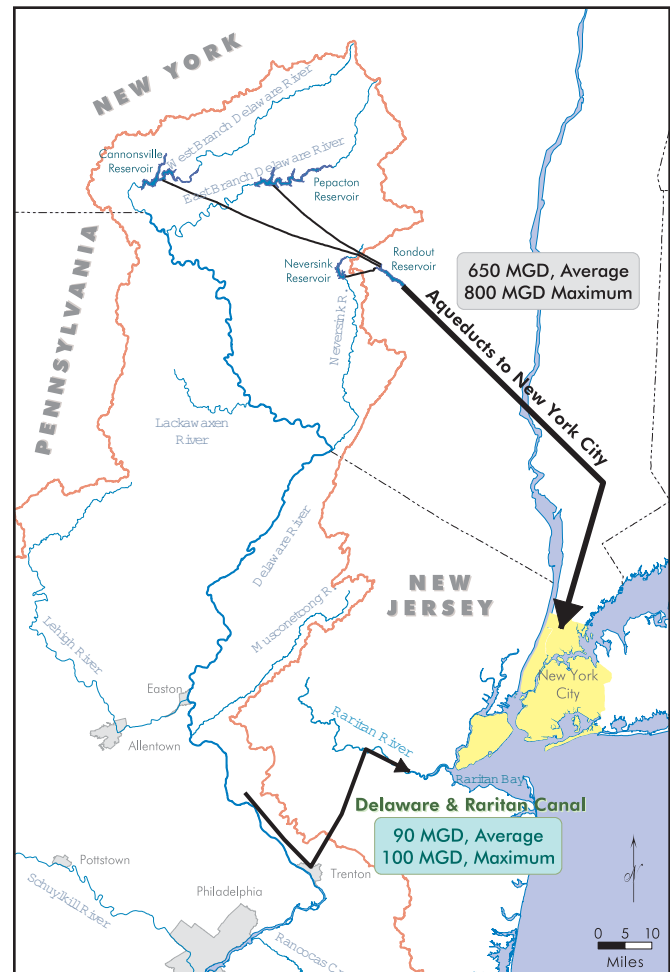
## DEFINING THE APPROPRIATE SCALE FOR ASSESSING WATERSHEDS

The Natural Resource Conservation Service (NRCS) and the U.S. Geological Survey (USGS) catalogue watershed units by Hydrologic Unit Code (HUC). The Delaware River Basin is comprised of twelve HUC 8 watersheds delineated by USGS. However, at an average of over 1,500 square miles, HUC 8 watershed units are too large for the purpose of developing more than rudimentary regional assessments. NRCS has catalogued 236 HUC 11 units that average about 55 square miles in size, although they can vary from a few to more than a hundred square miles in size. Smaller units (HUC 14 scale) number in the thousands, creating a practical barrier to developing a Basin-wide coverage of water budgets at that scale in the short-term. However, knowledge of watersheds at smaller scales may be most appropriate for local planning purposes, for assessing impacts, and for supporting restoration efforts. Choosing the correct watershed size depends on the purpose of the inquiry.

stable despite a growing population.

In response to actual and projected increases in water demand for the power generating sector, Merrill Creek Reservoir was constructed in 1989. During low-flow periods releases are made from the reservoir to offset the consumptive use at facilities that have purchased storage capacity in the reservoir, thus allowing them to continue operation where cut-backs in production would otherwise have been required. Substantial capacity in the Merrill Creek Reservoir is currently unused and is thus available for future purchase to offset consumptive use at new facilities.

**Figure 4: Major Water Exports**



**Calculating water budgets.** To help improve our understanding of how much water is safely available for use we need to understand water budgets on a watershed basis. A water budget is a description of the fate of water resources in a watershed, as illustrated in Figure 5. Budget “inputs” include precipitation and imports (transfers into the system). Water inputs will become:

- Evapotranspiration into the atmosphere
- Direct flows to surface water bodies (runoff)
- Indirect contributions to stream flow through the soil and water table
- Recharge to deeper ground water aquifers
- Consumptive losses associated with human use
- Exports from the watershed

The proportion of water inputs that arrive at each destination is determined by climate; geology, soils and topography; by the land use attributes of a watershed; and the way we use water resources. Water budgets yield an average annual accounting of water volumes and do not reflect seasonal variation. Although the water budget approach has limitations, pilot studies are under way as part of state water supply studies and a USGS-DRBC partnership to assess the feasibility of using water budgets as a screening tool for watershed assessments.

**Assessing in-stream flow and freshwater inflow requirements.** Understanding the needs of aquatic ecosystems is essential to several Goals of the Basin Plan, including:

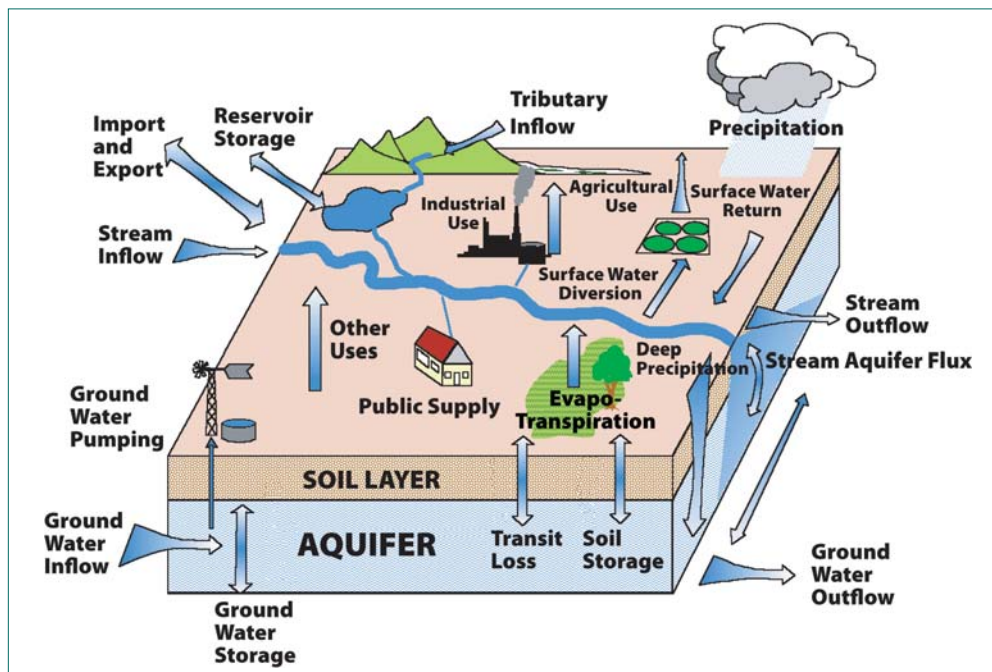
- Assessing the amount of water available for allocation
- Setting standards for improving conditions in watersheds and restoring natural functions in stream corridors
- Protecting threatened and endangered species
- Improving operating plans for reservoirs
- Setting appropriate criteria and standards for assessment and restoration within the Basin's ecoregions are necessary to make sustainable water allocation decisions.

**Developing strategies for the allocation of water.** Once both human and ecological needs are understood, the challenge of achieving an equitable balance of the multiple demands on the hydrological system can be addressed. Prudent allocation strategies may include curtailing water uses during drought conditions through allocation decisions or use restrictions, and allocating water to areas with limited water resources as determined by calculated water budgets and availability assessments. Allocation strategies also need to honor the rights of the parties defined in the 1954 U.S. Supreme Court Decree.

**Developing tools for assessing ecological integrity.** The development of indices of ecological integrity that integrate the physical, biological and chemical requirements of healthy aquatic and riparian ecosystems is critical for realizing restoration and enhancement goals as well as for developing appropriate water allocation strategies. Key species or characteristics that are especially sensitive to changes in water availability or quality should be identified. Understanding the relationship of

**Figure 5: Conceptual Water Budget**

(Source: Colorado Division of Water Resources, Office of the State Engineer)



## Sustainable Use and Supply

ecoregions, ecological communities, and watersheds is integral to the development and application of relevant assessment protocols.

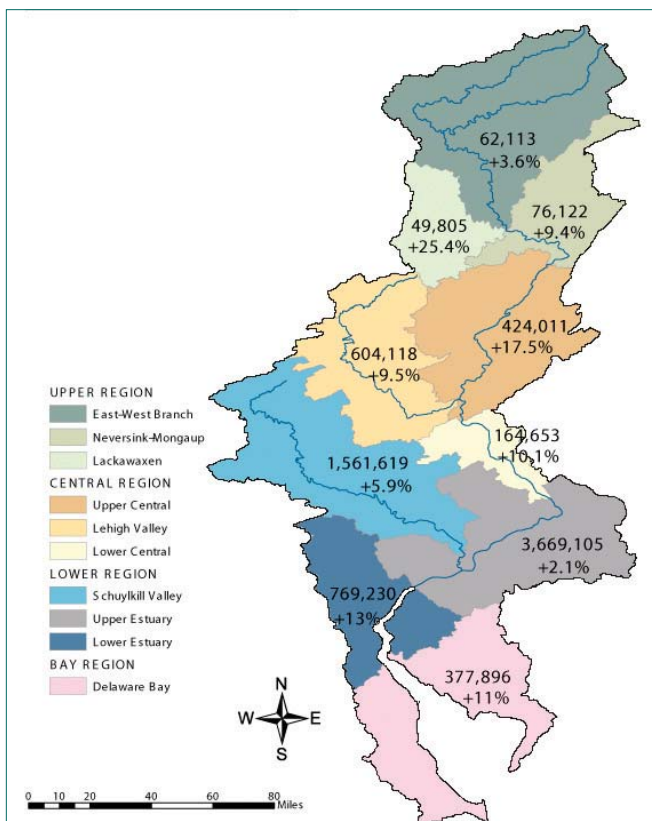
**GOAL 1.2: Ensure an adequate supply of suitable quality water to restore, protect and enhance aquatic ecosystems and wildlife resources.** Aquatic ecosystems and wildlife represent important users of the Basin's waters. Protecting water quality for those uses is an integral part of the Clean Water Act, and of federal and state laws and DRBC regulations.

**Identifying the freshwater needs for aquatic ecosystems and wildlife.** Fresh water must be available in adequate quantities for drinking, feeding, cleansing and reproduction. Resilient, healthy ecosystems adapt to changes within a natural range of variability. Changes that push the limits of that range may cause irreparable harm to communities of water-dependent animals and plants. Therefore, it is important to understand ecosystem function, and the limits to the range of conditions that ecosystems and natural communities will tolerate.

**Water availability varies with geographic location and seasonal fluctuations in precipitation and temperature.** It is also susceptible to change as a result of the patterns of human settlement and water use. For example, the ways in which water is allocated to uses within and outside of the stream (public water supply, industrial, commercial, agricultural, power production, etc.) and how water is returned to the stream (when,

where, in what amounts, and of what quality) can have a great influence on how streams provide for ecosystem needs.

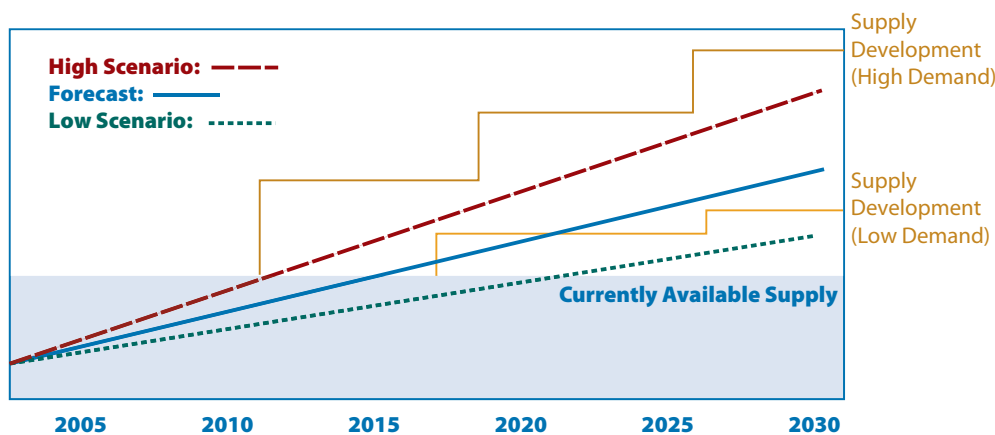
**Figure 6:** 2000 Population by Region Showing Percentage Change From 1990



**GOAL 1.3: Ensure an adequate and reliable supply of suitable quality water to satisfy public water supply and self-supplied domestic, commercial, industrial, agricultural, and power generation water needs.** Projecting demand for water for various human purposes includes identifying how much, when, and where water will be needed. Before we can ensure adequate water resources for human purposes into the future, we need to generate projections of population and sector water demand. These projections can then be compared to the water determined (through the water budget and available ground water assessments) to be available for allocation — that is, available for use without impairing the ability of the water resource base to support healthy ecosystems. This will require developing a methodology and range of assumptions to which the Basin partners are agreeable. Figure 6 shows regional population change in the Basin between 1990 and 2000.

**Projecting water needs for all use sectors, must consider estimates of consumptive use, water distribution system losses and the potential effects of various water conservation programs.** Projections must also take into account possible alternative future conditions. This requires making a range of projections, reflecting a variety of possible scenarios. Figure 7 illustrates how differing future water demand scenarios require different levels of water supply development. This Plan requires that a study of future water demands be undertaken to enable us to plan the necessary supplies for the next 30 years. While we can focus on what the most likely (forecast) outcome will be, we can also examine the cost and benefits of alternative (high and low) water demand scenarios and the implications for resource development. This approach also provides a method for testing the sensitivity of water use projections.

**Figure 7:** Schematic Representation of Scenario-based Water Demand Forecasting



**Ensuring adequate supplies for future populations.** This entails understanding and managing how and where growth will occur in order to fulfill expected demand and have the least detrimental impact on natural systems. If water stressed areas are identified for growth, then solutions to water supply problems need to be determined and planned. Lessons learned and legal constraints established in connection with previous decisions on water transfers should be incorporated into water resources decision-making in the future to meet state, regional and local plans for growth management as well as ecological needs.

The map in Figure 8 shows existing population density in the Basin regions as of 2000, and areas in Pennsylvania and New Jersey where special withdrawal restrictions are in effect based on concerns for ground water levels.

**GOAL 1.4: Ensure adequate and suitable quality stream flows for flow-dependent recreational activities.** Assessing the flows needed for recreational purposes and planning for flow management includes:

- Defining the scope of flow-dependent recreational activities
- Determining the needs of these activities
- Setting operation strategies to be applied during periods of normal and subnormal precipitation in the areas of the Basin where reservoir releases are managed

## Sustainable Use and Supply

- Examining legal restrictions on the use of reservoir storage

Flow-dependent recreational activities in the Basin, such as boating, swimming and fishing, not only provide important physical, social and cultural benefits to Basin residents and visitors, but they also comprise an important sector of the Basin's economy. Tourism dollars from the boaters, canoeists, anglers, and other participants in water-dependent activities in the Basin are becoming increasingly important. Recreation uses are also protected under the Clean Water Act's "fishable and swimmable" requirements. For all of these reasons, it is important that recreational use of waterways continues to be valued and protected.

### An Adequate Supply of Suitable Quality Water

The discussion thus far has focused primarily on determining and maintaining adequate supplies for human and ecosystem needs. However, a sustainable use of water resources also requires that, in using those resources, the quality be maintained at a level that is adequate, both now and into the future, for all uses. Therefore, a true measure of water availability must also include water quality. Because many human activities have the potential to impact water quality, it is necessary to understand the nature of those impacts, including those that have

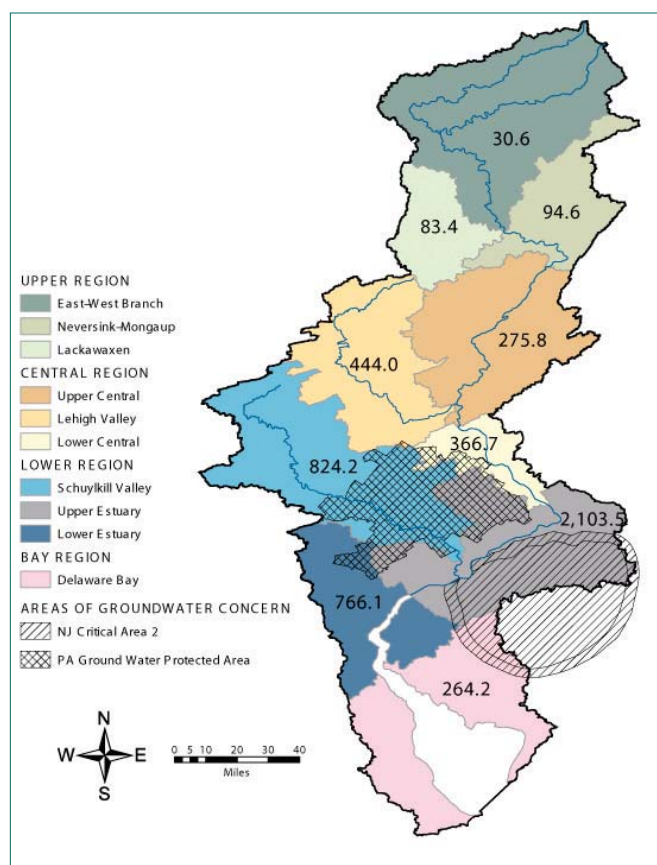
occurred, those that are occurring, and those that may occur in the future. Assessing the current quality of the Basin's water resources, while identifying trends and potential impacts, is an ongoing component in the process of maintaining or improving water quality.

**Assessing water quality.** Ensuring that water quality meets or exceeds the needs of its intended use requires it to be assessed. To determine the actual quality of water in a stream or aquifer requires field measurements and laboratory analysis. Data must be collected over a period of time to adequately reflect the natural range of hydrologic and climatic factors which affect water quality. A significant commitment of time and resources is necessary because information needs to be collected for a duration sufficiently representative of the natural variations or changes expected to occur in natural systems.

Water quality must be monitored and assessed with sufficient frequency and consistency to determine if the water quality is being maintained, improved or degraded. Strong coordination and cooperation among Basin partners is critical to ensure the development, implementation and monitoring of a comprehensive set of criteria and indicators that define the quality of Basin waters. Specifically, Basin partners must be able to coordinate the multi-jurisdictional monitoring

efforts, agree on methodologies and criteria for sampling and assessment, and provide consistent and timely advice to the water resource community.

**Figure 8:** 2000 Population Density, Persons per Square Mile



Coordination and cooperation is also necessary to make the most efficient use of limited fiscal and staff resources, and to provide adequate and reliable data.

- **Basin partners face the multiple challenges of building on existing monitoring and indicator programs, establishing robust sets of indicators for each of the Objectives in this Plan, and implementing a coordinated monitoring network to accurately assess water quality trends in the Basin.**

**Maintaining water quality.** This requires setting water quality criteria and agreeing on permitting standards for discharges as well as providing tools and information that will prevent additional impacts from land development and management activities. Approaches may include:

- Anti-degradation programs (e.g. designated uses, state protections for high quality and exceptional value streams, the DRBC's Special Protection Water designations and federal Wild and Scenic Rivers designations)
- Stormwater management programs
- Water quality-based trading programs (offsetting impacts from discharges by equivalent reductions from other sources within the watershed)
- **A major challenge is to "keep our clean water clean" in areas with expected future increases in growth and development activity.**

**Improving water quality.** Where standards are not being met for designated uses, regulatory and non-regulatory strategies must be developed to identify pollutant sources and to achieve the standards. Maximum Contaminant Levels (MCLs) for drinking water and ambient water quality have been set for many parameters. When monitoring reveals problems with any given substance of concern, the next step is to identify the source of the problem. For example, high levels of nitrates in well water can be attributed to a number of sources; faulty septic systems, the application of agricultural fertilizers, and livestock operations are the most likely sources in our region. Tracking the sources and taking steps to reduce or eliminate the contamination may require the participation and cooperation of health, environmental and agricultural agencies as well as property owners and managers.

The Basin states and the Commission are currently engaged in the development of Total Maximum Daily Loads (TMDLs) for certain pollutants surface water bodies in the Basin. The TMDL program is targeted at point and nonpoint sources of pollutants of concern that prevent the attainment of a water body's designated use. TMDLs are developed for each of the pollutants causing the impairments with load allocations assigned to both point sources and nonpoint sources. Changes are made to effluent requirements in the National Pollutant Discharge Elimination System (NPDES) permits based on these load allocations. Nonpoint source reductions are also identified, and the application of Best Management Practices (BMPs) can be utilized to achieve the necessary reductions. BMPs can include changes in fertilizer type and use, greenways, etc.

Depending on the pollutant of concern, other approaches to achieve the necessary pollutant reductions may also be effective. For example, a pollutant trading program, in which credit for greater reductions than required in the NPDES permit achieved at one or more point sources, may be traded to other point sources to realize the overall load reduction. Similarly, pollutant reductions in some nonpoint sources can be traded with other nonpoint or point sources to



## Sustainable Use and Supply

### **WATER QUALITY — VALUE OF STREAMBANK STABILIZATION**

Streambank stabilization to reduce erosion also removes substantial quantities of phosphorus from nonpoint sources. Phosphorus is a nutrient that contributes to unwanted algal growth and the reduction of dissolved oxygen in streams and lakes.

Reduction in the amount of phosphorus (along with sediment and nitrogen) associated with streambank stabilization provides potential economic benefit through reduced treatment costs and adverse environmental impacts.

Source: U.S. Army Research and Development Center  
[www.wes.army.mil/el/wq](http://www.wes.army.mil/el/wq)

attain the required reductions. Pollutant trading programs can be more cost effective and result in reaching required reductions more quickly than traditional pollutant reduction programs.

- **The challenge to Basin partners is to utilize both traditional and innovative strategies, and to develop, implement and monitor the effectiveness of these strategies toward the desired result — the mitigation of existing water quality impairments and the prevention of future impairments from growth and development.**

**Protecting source water.** Ensuring adequate supplies also involves protecting source waters and ensuring against delivery disruption due to deliberate or accidental contamination or system damage. In the late 1980s, as part of the federal Safe Drinking Water program, states were required to develop Wellhead Protection Programs to protect vulnerable community supply wells. However, successful application of the generally voluntary state programs has been hampered by inconsistent municipal involvement, as well as funding and legal difficulties.

Amendments to the federal Safe Drinking Water Act in 1996 initiated the Source Water Assessment Program (SWAP) to evaluate existing and potential threats to the quality of public drinking water. By 1999, states had to delineate source water protection areas, inventory sources of contamination, and determine susceptibility of systems to contaminant sources.

Threats to national security and public welfare in the wake of September 11, 2001 have heightened awareness of the need to secure from harm the waters that serve as potable public supply and their distribution systems. As a result, security efforts have increased at many facilities. Federal requirements for Source Water Assessment Programs, include determining the vulnerability of source water supplies and taking steps to protect them. Regional coordination of contingency plans and protection measures is necessary to ensure minimal disruption of supplies in emergencies. Detection and warning systems to alert water supply managers of accidental spills or deliberate contamination of water supplies is an integral part of emergency preparedness.

**Ensuring “fishable” waters.** Certain chemicals and toxins bio-accumulate in the flesh of fish. When accumulation reaches levels higher than those deemed safe for human consumption, states post health advisories against eating even limited amounts of certain species from specified water bodies or stream segments. In addition to the food chain impacts and implications for human health, the quality and abundance of fish species also affects the viability of commercial and recreational fishing and associated tourism economies.

- **The presence of persistent and bioaccumulative compounds in our waters and the associated potential for human and ecological health effects is an emerging issue for water resource management. See “Key Result Area 4: Institutional Coordination and Cooperation” for more about emerging issues.**

“Key Result Area 1: Sustainable Use and Supply” encompasses the issues associated with using the Basin’s waters as a sustainable resource, and the need to consider water quality, quantity and flow characteristics when managing its use. Water quality, quantity, and particularly its flows, are affected by adjoining portions of the landscape that directly interact with streams and rivers. Riparian lands, along with

the waters that flow through them, comprise the waterway corridors that provide habitat for aquatic life, recreational opportunities, flood control and a host of other benefits worthy of protection and enhancement. The next section of this Plan, “Key Result Area 2: Waterway Corridor Management,” addresses the issues specific to improving the management of our waterway corridors.

### Unique Aspects of the Delaware River Basin

The Delaware is the longest undammed river east of the Mississippi.

Roughly half of New York City’s water comes from Delaware River headwater reservoirs. The Delaware and its tributaries supply water to Philadelphia and a cluster of other nearby riverbank cities, which collectively comprise the world’s largest freshwater port.

The Delaware River winds through Pennsylvania’s Lehigh Valley, where America’s Industrial Revolution began.

The upper Delaware flows beneath the Roebling Aqueduct, which was engineered by John Roebling designer of the fabled Brooklyn Bridge. It is said that the aqueduct bridge is the oldest existing wire suspension bridge in the United States.

The Delaware River has attracted writers and painters. Walt Whitman discovered poetry in its commerce.

Rudyard Kipling described the Revolutionary battle of Valley Forge in his verse. Thomas Eakins painted sailboats skipping over the white-capped waves of Delaware Bay.

At a riverbank ceremony in 1996, former Delaware Governor Thomas R. Carper remarked “The cleanup of the Delaware has been heralded as one of the world’s top water quality success stories.”

As a result of a remarkable comeback in water quality and a growing appreciation of her myriad attractions, much of the Delaware River and portions of several tributaries today are part of the National Wild and Scenic Rivers System.

The upper Delaware River watershed is home to the largest population of wintering bald eagles in the northeastern United States. This is largely due to programs to protect high water quality and preserve critical habitat.

The tidal reaches of the Delaware, along with the Delaware Bay, are part of the National Estuary Program, a project initiated in 1988 to protect estuarine systems of national significance.

The Delaware Bay is the principal breeding ground for American horseshoe crabs on the East Coast, and is among the largest staging areas for shorebirds in North America.

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